Letters to the Editor.

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Restoration of Energy.

CONCERNING the pressure of light, we may safely say that it was predicted by Maxwell, discovered by Lebedew of Moscow, and independently by Nichols and Hull in America; while it was elaborately discussed, clinched by further experiments, and its significance greatly extended by Poynting and by Poynting and Barlow. We now learn from Prof. Eddington's brilliant address to Section A of the British Association at Cardiff this year that radiation pressure has a cosmic significance beyond what had been thought possible; that it holds back or sustains the outer substance of the brighter and hotter stars, and is responsible for their huge size; while at the same time it has the effect of limiting the possible aggregation of masses of matter, so that the mass reasonably permissible to any star ranges from five times to one-half that of our sun—something of that order.

According to Prof. Eddington's calculations, the radiation from an exceedingly hot central nucleus, heated it may be by atomic disintegration, acts like a rushing mighty wind on the outer portions, and sustains them against gravitative attraction;—surely a remarkable example of the significance inevitably attaching to the most minute and barely detectable forces. So long as any given kind of force exists at all, it may under proper conditions have an overpowering and surprising effect.

I write to convey a verbal suggestion made by my assistant, Mr. Edward E. Robinson, a year or two ago, that light-pressure may afford an escape from some popular eschatological conclusions based on the doctrine of the dissipation of energy. Engineers like Prof. Osborne Reynolds and Sir William Siemens have deplored the waste of solar energy, of which so minute a fraction is caught by the earth or any planet, and have sought to circumvent and reconcentrate it somehow—by total reflection at an æthereal boundary or otherwise. And when we think of the vast store of power ceaselessly being radiated from every star, and apparently fruitlessly lost in the depths of space, it is natural to look either for some usefulness in the torrent or for some sort of compensating mechanism. So also, under the influences of gravitative attraction and the general law of dissipation of energy, it has seemed to some as if the cosmos was tending towards a cosmic tomb—consisting of one large cold or cooling lump of matter, with all the energy of its gravitative falling together wasted by radiation into the depths of space, and no recovery possible, nor any more generation of heat.

But what about the sweeping or propelling power of that apparently waste radiation? It exerts pressure on matter; particles of suitable small size must be swept along with it. Why should we not contemplate a constant sweeping of cosmic dust away towards infinity, with full power of return when sufficiently re-aggregated? Is there not some hope of restitution and restoration in this, so that gravitative fall can once more recur and the whole cycle begin again?

To estimate the amount of matter which can thus be repelled, taking into account diffraction effects, is rather complicated. It must not be enough at any one time to cause effective opacity; but, considering the speed generated by any small acceleration in free space and the length of time available, the total amount of repelled matter need not be inferior to the amount of disintegrated material which collisions and friction and eruptions and electrical repulsion are likely to provide. *Something* preserves the transparency of space; may it not be this constant sweeping away of dust? Far away from any source of radiation the particles would not be hot enough to repel each other, so there would be nothing to prevent their beginning to collect together, and so preparing to fall once more from practical infinity.

Electrified particles, ions and electrons, of which interplanetary space must contain myriads, are also propelled by light. But these seem to attain a terminal velocity, of value depending on the intensity of the radiation and the square of its wave-length. Long waves travelling in space would therefore be most effective, but short waves would act in the right direction; and the electrons thereby driven among the cosmic dust—exerting mutual forces much stronger than gravitation—might act as the cement to weld it together again.

So long as matter is being accelerated by radiation-pressure, and so long as fresh ions are being produced in its path, the energy of the radiation would tend to be consumed. Hence the ultimate result of all the otherwise waste radiation might be just that energy of gravitative separation which is required for a new Lucretian universe.

There are other possibilities, of too speculative a character, depending on the semi-material nature of light. The suggestions so far made may be negatived, but they seem worth putting forward in a tentative manner.

OLIVER LODGE.

British Laboratory and Scientific Glassware.

I HAVE no interest in the manufacture of scientific glassware, except in so far that as I devoted most of my time to the subject during the war I should like to know that my work would lead to permanent results. I may, therefore, be permitted to address a word to users and manufacturers of scientific glassware.

To users I say: Use only scientific hollow-ware which bears the maker's name; and if you find it faulty, send it straight back to the manufacturer, whom you will be assisting, and who will replace it at once. Even the famous Jena glass was often faulty, and while working in the laboratory in the autumn of 1914 it was not only once that Jena beakers were found to have cracked without apparent cause. On two occasions I actually heard beakers crack while they were standing on the table.

In the autumn of 1914 I worked out the resistance glass and lamp-working glass which have been spoken of as standing at the head of the list, and early in 1915 I began to manufacture these glasses, and continued to do so throughout the war, maintaining the original compositions, but modifying the batch formulæ as different materials became available. The glasses were worked out on the basis of analyses of a large number of foreign glasses and a study of their properties. The investigation was a perfectly straightforward one, and no particular difficulty attached to it, and I will even admit that luck came to the aid of judgment in arriving at the final conclusions.

I am making this statement because I wish it to be recognised that a misunderstanding exists as to the difficulties which had to be overcome in connection with the manufacture of scientific glassware, and not because I wish to lay claim to particular credit for carrying through a simple piece of work. The real

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difficulty lay in the working out of methods of manufacture, particularly the devising of mechanical methods, and in imposing them upon an industry which was rather unwilling to adopt them. The glassmaker's chair and tools had to be replaced by moulds, and even then the procedure adopted in mould-blowing as practised in the country had to be modified. Instead of employing men to finish such articles as beakers, machines had to be devised to carry out the processes which could be operated by girls. Drastic alterations in the methods of annealing had to be introduced. In some branches, such as the manufacture of graduated ware, the technical processes for production in mass had to be worked out from the commencement.

Now the fullest information as to the composition of German chemical glassware was at the disposal of anyone who had access to a chemical laboratory, such as Prof. Baker kindly placed at my disposal in October, 1914, and could make an analysis of glass. The reproduction of these glasses, on the basis of the analyses, called for some knowledge of commercial materials, and such information as was available as to the qualities of the glasses actually on the market made improvement a matter of no very great difficulty. If the chemical problems had been the essential ones the scientific public would have had every reason to complain if the manufacturers had not at the outbreak of war at once produced perfectly satisfactory scientific glassware, and had never failed to give them the most complete satisfaction. However, the actual fact is that the chemical difficulties were almost non-existent; but, on the other hand, the technical difficulties were very real, involving the expenditure of a vast amount of energy and money which had to be provided by the manufacturers themselves. I can say most definitely that all those who have been concerned in the industry have actually lost money in the venture, but that they do not grudge the cost.

During the war a vast amount of information was collected and shared between the various firms engaged in the industry, but it was often impossible to make use of it owing to the difficulties which stood in the way of obtaining machinery and plant. It would now be possible to make use of this information, to reorganise completely factories for mass production, and to install new plant, but the manufacturer is hampered by the stringency of the financial position, the enormous increase in the cost of machinery, etc., and the absolute uncertainty as to the policy of the Government. However, if the industry is doing its best to meet the situation, it deserves the support of the scientific public, which has also the right to demand guarantees. I suggest, therefore, that the manufacturers should invite the Institute of Chemistry and the Institute of Physics, which represent the professions most closely concerned, to investigate the position of the industry and to report upon it.

It must not be imagined that the cost of scientific glassware will ever approach the pre-war standard, and it does not appear that the increase in cost is in excess of the increase in cost of other commodities. During the war, while I had the opportunity of checking the figures, I know that our prices were lower than the pre-war prices relatively to the increase in the cost of production. Temporarily, owing to the rate of exchange, German glass is obtainable at a lower rate than English, but if this fact is taken advantage of now, the scientific public is likely to have to pay for its short-sighted policy so soon as the industry is once more completely in German hands.

M. W. TRAVERS.

November 6.

Negative Electron Curve.

THE elements are constructed, so it is now believed, of collections of hydrogen atoms bound together by negative electrons. The atomic weight of an element is not, as a rule, a whole number. I think the importance of this departure from integers is most significant.

If we can consider that the element is composed of a number of hydrogen atoms, then the departure from the simple sum of the weight of the hydrogen atoms composing the element must be due to the negative electrons. For example, the element vanadium has an atomic weight of 51·06. Suppose we consider it to be composed of 51 hydrogen atoms, then its atomic weight should be 1·008×51=51·408; but its atomic weight is 51·06. The difference is −0·348, due, I take it, to the negative electrons which have entered into the composition of the element.

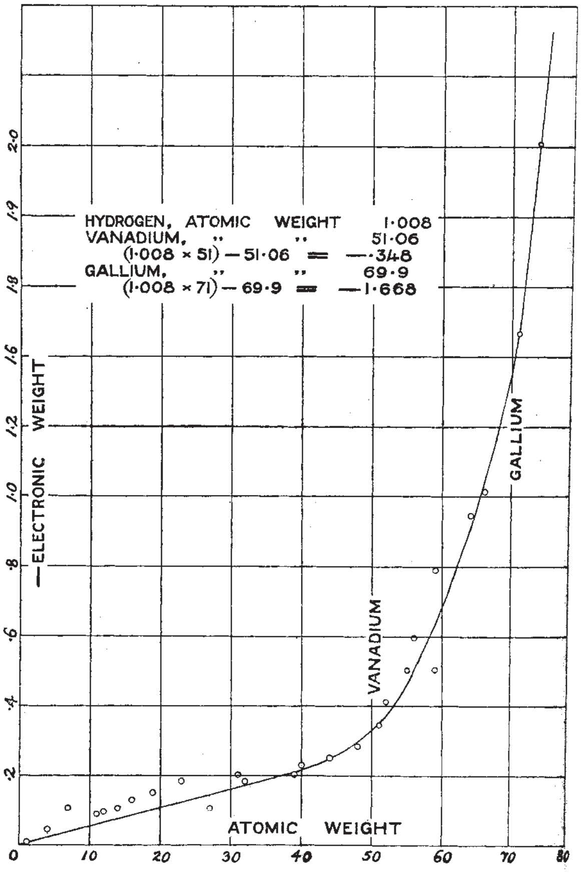

FIG. 1.

I have obtained *minus* quantities for a number of the elements, starting from hydrogen, atomic weight 1·008, and stopping at Ge, and I find that they space themselves along a regular curve, as shown in Fig. 1. That the *minus* quantities of the atomic weights should have arranged themselves in this regular way by pure accident I cannot believe, so I suggest that there is some natural law at work to account for it. The explanation is to be sought, I think, in the supposition that the hydrogen atoms attract each other, producing the force of gravity, while the negative electrons are repulsed by gravity; the elements are, therefore, lighter than the sum of the hydrogen atoms themselves.

Referring again to the curve, if the helium atom is

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